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**PAVEMENT TESTING -- BEFORE
AND AFTER AN OVERLAY**

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0. Abstract

A pavement scheduled for an overlay of 76 mm (3 inches) of asphaltic concrete on one half the project and 178 mm (7 inches) on the other half was tested and evaluated at two sites for each thickness of overlay. Precise elevations were obtained on 0.305-m (1-foot) intervals across the pavement. The Road Rater and Benkelman beam were used to determine the in-place behavior of the pavement before and after construction of the overlay. Prior to placement of the overlay, the pavements were cored to determine actual layer thicknesses, and in-place CBR tests were performed to determine actual subgrade conditions.

Analysis of Road Rater deflections permitted determination of the "effective" thickness of the old existing pavement in terms of the actual thickness of the crushed stone base and an equivalent thickness of asphaltic concrete of "reference" quality materials. Three months after the overlay had been constructed, the test sites were revisited, Road Rater tests made, and precise levels determined on 0.305-m (1-foot) intervals across the pavement. Thus, actual overlay thicknesses could be determined. Analysis of the Road Rater deflections confirmed the overlay thicknesses.

1. Design Assumptions

KY 33, an access road to a steam-generating electrical plant that uses coal, was scheduled for a structural overlay. Future developments would involve a facility on a nearby river for unloading coal barges. Coal would be transferred by truck to the plant over KY 33. Such a significant change in traffic conditions required a strengthening of the pavement structure.

The following assumptions were made to estimate expected 80-kN (18-kip) equivalent axleloads (EAL):

1. Available space at the river would limit the size of trucks to a single unit having three axles.
2. Capacity of the unloading machinery would be limited to six trucks per hour (48 trips per day).
3. A barge would be unloading at the facility 125 working days each year.
4. The equivalent damage factor per trip would be 22.5 EAL for this size and style of truck.
5. The design should last six years.
6. Volume of automobile traffic was considered to be relatively insignificant for this location.

The total calculated 80-kN (18-kip) EAL anticipated was

$$\text{EAL} = 48 \text{ trips per day} \times 125 \text{ days per year} \times 6 \text{ years} \times 22.5 \text{ EAL per trip} = 4,810,000 \text{ EAL.}$$

2. Evaluation of Pavement Performance [6]

The Road Rater was used to evaluate the existing pavement. Historical records were searched to determine the thicknesses of each layer. Cores were taken at the test sites. Elevations were measured on 305-mm (1-foot) intervals across the pavement at each test site. Surface temperature, time of day, frequency of testing, and Road Rater deflections were measured at each site.

A temperature distribution for the asphaltic concrete layer was obtained using the pavement surface temperature, time of day, and 5-day mean air temperature. The corresponding distribution of moduli was obtained using previously published procedures [5]. A mean pavement temperature and asphaltic concrete modulus was determined and used to select the appropriate factors required to adjust field-measured Road Rater deflections to reference conditions: 21.1°C (70°F), 25 Hz, Modulus of Elasticity of Asphaltic Concrete = 8.27 GPa (1,200 ksi).

Theoretical relationships between Road Rater deflections and subgrade modulus of elasticity were developed for the constructed pavement thicknesses for before and after placement of the overlay. Core data were used as the basis for actual before overlay pavement thicknesses. Differential elevations were used to determine pavement thicknesses after construction of the overlay.

Deflection measurements were made at all four sites before asphaltic concrete overlays were constructed [5]. Adjustments were made to reference conditions and data were evaluated for each site. Pavement behavior was expressed in terms of a reduced (effective) pavement thickness of reference quality materials and an effective subgrade modulus. Procedures used in estimating the effective thickness and effective subgrade modulus have been described elsewhere [2, 3, 4, 7]. Results of the before overlay pavement evaluation are presented in Table 1.

Deflection measurements were made approximately three months after overlaying at the same test locations. The deflection measurements were analyzed in terms of the initial pavement thickness plus the overlay thickness. Results of the after overlay analysis for the four sites are presented in Table 2. The effective overlay thickness for any given point is equal to the difference between the effective thicknesses of asphaltic concrete for before and after overlay testing. Computation of effective overlay thicknesses is presented in Table 3. The average effective overlay thickness for each site is also presented in Table 3. Ratios of the average effective overlay thickness (T_{EO}) to the average constructed overlay thickness (T_O) as determined from differential elevations are also presented in Table 3.

The analysis presented in Table 3 indicated an average effective overlay thickness slightly less than the average constructed overlay thickness. Dynamic tests were made approximately three months after overlay construction was completed. It is possible that the newly constructed asphaltic concrete layers may not have had sufficient time to reach maximum potential strength. This condition has been observed at other test locations. The time required for an asphaltic concrete overlay layer to reach its maximum strength may be a function of the total thickness of the overlay. The total overlay thickness may be made up of one or more thinner layers placed within a short period of time. Curing time for an asphaltic concrete layer may be a function of the distance volatiles must travel to a free face. Such curing rates may be analogous to the primary and secondary consolidation rates associated with soil mechanics.

Estimates of effective subgrade moduli were also determined from before and after overlay dynamic deflection tests (Tables 1 and 2). In-place CBR tests were made at each site before construction of the overlay began but were not made simultaneous to dynamic deflection testing. The average effective subgrade moduli estimated from dynamic deflection data and the average subgrade moduli as estimated from in-place CBR measurements are presented in Table 4. Subgrade modulus in psi may be estimated from CBR values by multiplying by 1500 [1]. It can be noted from Table 4 that fall estimates of subgrade moduli are normally greater (stronger) than spring. This is considered normal. Testing at other sites has indicated similar variations [2]. In two instances, spring estimates of subgrade modulus from in-place CBR tests exceeded estimates from dynamic deflection testing. This is not totally surprising. The in-place CBR test is basically a pene-

tration test and is confined to a small area. On the other hand, dynamic deflections result from a much larger area of influence. This might account for the greater amount of variability in moduli estimated from in-place CBR tests as compared to estimates from dynamic deflection tests.

3. References

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TABLE 1 PAVEMENT BEHAVIOR BEFORE OVERLAY

T_{AC} = Constructed Thickness (inches) of Asphaltic Concrete From Core Measurements								
T_{DGA} = Constructed Thickness (inches) of Crushed Stone From Core Measurements								
T_{EB} = Effective Thickness (inches) of Asphaltic Concrete From Dynamic Deflection Tests Before Overlaying								
E_{SB} = Effective Modulus (psi) of Subgrade Before Overlaying								
Date of Deflection Testing = March 25, 1975								
Test Location	Site 1		Site 2		Site 3		Site 4	
T_{AC}	4.5		4.5		5.9		6.3	
T_{DGA}	5.0		5.0		5.0		5.0	
	T_{EB}	E_{SB}	T_{EB}	E_{SB}	T_{EB}	E_{SB}	T_{EB}	E_{SB}
1-1	4.25	16,000	4.2	9,200	5.1	10,250	6.0	13,250
1-2	4.00	14,000	4.0	13,250	5.3	15,000	5.5	10,250
1-0	4.10	9,900	3.9	13,250	5.6	13,000	5.9	13,750
2-1	4.00	17,000	4.0	9,800	5.7	11,500	5.0	9,200
2-2	4.00	13,500	4.2	10,750	5.8	11,500	6.0	8,000
2-0	4.45	10,250	4.5	9,300	5.4	12,250	6.0	10,750
T_E	4.1		4.1		5.5		5.7	
σ_{TE}	0.18		0.20		0.26		0.41	

TABLE 2 PAVEMENT BEHAVIOR AFTER OVERLAY

T_O = Thickness (inches) of Asphaltic Concrete Overlay (Average From Elevation Measurements)

T_{AC} = Constructed Thickness (inches) of Asphaltic Concrete Before Overlaying (From Core Measurements)

T_{DGA} = Constructed Thickness (inches) of Crushed Stone From Core Measurements)

$T_A = T_O + T_{AC}$ = Thickness (inches) of Asphaltic Concrete After Overlaying

T_{EA} = Effective Thickness (inches) of Asphaltic Concrete From Dynamic Deflection Tests After Overlaying

E_{SA} = Effective Modulus (psi) of Subgrade After Overlay

Data of Deflection Testing = November 6, 1975

Test Location	Site 1	Site 2	Site 3	Site 4
T_{AC}	4.5	4.5	5.9	6.3
T_{DGA}	5.0	5.0	5.0	5.0
T_O	3.0	3.8	7.7	7.0
T_B	7.5	8.3	13.6	13.3
	T_{EA} E_{SA}	T_{EA} E_{SA}	T_{EA} E_{SA}	T_{EA} E_{SA}
1-1	7.0 16,000	7.8 16,500	10.5 13,000	13.0 18,500
1-2	7.0 24,000	7.8 18,000	10.9 20,500	11.0 25,000
1-0	7.5 23,000	7.9 19,500	12.0 19,500	11.0 25,000
2-1	6.8 16,000		11.5 14,000	8.5 25,000
2-2	6.8 25,000	7.4 16,000	13.0 20,500	9.2 21,000
2-0	6.4 20,500	8.0 18,000	13.0 19,500	11.5 21,000
T_E	6.9	7.8	11.8	10.7
σ_E	0.36	0.20	1.05	1.62

TABLE 3 DETERMINATION OF EFFECTIVE OVERLAY THICKNESSES

T_{EB} = Effective Thickness (inches) of Asphaltic Concrete From Dynamic Deflection Tests Before Overlaying

T_{EA} = Effective Thickness (inches) of Asphaltic Concrete From Dynamic Deflection Tests After Overlaying

$$T_{EO} = T_{EA} - T_{EB}$$

Test Location	Site 1	Site 2	Site 3	Site 4
	$T_{EA} - T_{EB} = T_{EO}$	$T_{EA} - T_{EB} = T_{EO}$	$T_{EA} - T_{EB} = T_{EO}$	$T_{EA} - T_{EB} = T_{EO}$
1-1	7.0-4.25 = 2.75	7.8-4.2 = 3.6	10.5-5.1 = 5.4	13.0-6.0 = 7.0
1-2	7.0-4.00 = 3.00	7.8-4.0 = 3.8	10.9-5.3 = 5.6	11.0-5.5 = 5.5
1-0	7.5-4.10 = 3.40	7.9-3.9 = 4.0	12.0-5.6 = 6.4	11.0-5.9 = 5.1
2-1	6.8-4.00 = 2.80		11.5-5.7 = 5.8	8.5-5.0 = 3.5
2-2	6.8-4.00 = 2.80	7.4-4.2 = 3.2	13.0-5.8 = 7.2	9.2-6.0 = 3.2
2-0	6.4-4.45 = 1.95	8.0-4.5 = 3.5	13.0-5.4 = 7.6	11.5-6.0 = 5.5
\bar{T}_{EO}	2.78	3.62	6.33	4.97
$\sigma_{T_{EO}}$	0.47	0.30	0.90	1.47
\bar{T}_{EO}/T_O	2.78/3.00 = 0.93	3.62/3.8 = 0.95	6.33/7.7 = 0.82	4.97/7.0 = 0.71

TABLE 4 ESTIMATED SUBGRADE MODULI (PSI)

Test Location	From In-Place CBR Tests	From Dynamic Deflection Tests	
	April 22, 1975	March 25, 1975	November 6, 1975
1	24,750	13,442	20,750
2	4,650	10,925	17,600
3	13,425	12,250	17,833
4	26,475	10,867	22,583